

77035

DRAFT

Impact Melt Breccia

5727 grams



Figure 1: Photo of “norite” clast in 77035,23. Round prop is about 3.5 cm. NASA photo # S78-27393.

## Introduction

Sample 77035 is an impact melt rock that has partially dissolved the original clasts or welded them into its recrystallized matrix such that they cannot be easily extracted. It has fine-grained flow-banded matrix and contains several clasts including one large, pristine clast of norite (figure 1). 77035 has not been dated.

## Petrography

The main mass of 77035 is a micropoikilitic impact melt breccia, apparently similar to the large boulders at stations 6 and 7 (Simonds et al. 1974). However, careful observation of the sawn surface (figure 2) shows that the matrix includes numerous, small, aphanitic, dark grey clasts, welded together in a “marble cake” pattern. The presence of these aphanitic clasts distinguish this sample from the boulders (figures 2, 11).

## Significant clasts

The large white clast (~100 grams) in 77035 (seen in figure 1) has been studied by Warren and Wasson (1979) and Warren and Kallemeyen (1984). Warren (1993) lists this clast as probably “pristine”. It is a cataclastic norite with approximately 60% plagioclase  $An_{93}$  and 40% orthopyroxene  $W_2En_{89}Fs_9$  (figure 4). However, it is highly shocked with part of the mineralogy converted to diaplectic glass. The composition is given in table 1 and figure 7.

Eckert et al. (1991), Neal et al. (1992) and Neal and Taylor (1998) have studied additional lithic clasts extracted from 77035. They analyzed one “dunite”, two “norite”, and two “anorthositic” clasts. It was difficult to extract them cleanly from the matrix.

Dunite clast ,226 is essentially all olivine ( $Fo_{80-89}$ ) and has a deep Eu anomaly (figure 8).



Figure 2: Sawn surface of 77035,23. Sample is about 6 inches across. NASA #S89-44217.

Gabbronorite clast , 229 has ~75% plagioclase ( $An_{85-87}$ ), ~11% orthopyroxene ( $En_{71-72}$ ), ~11% high-Ca pyroxene ( $W_{43}En_{44}Fs_{13}$ ) and 3% olivine ( $Fo_{69-73}$ ). It has a positive Eu anomaly and is reported as pristine by Neal and Taylor (1998).

Clast ,206 has 37 ppm Ir and a flat REE pattern (figure 8). It has about 66% plagioclase ( $An_{93-96}$ ), 12% low-Ca pyroxene ( $Wo_4En_{73}Fs_{23}$ ), 14% high-Ca pyroxene and 7% olivine ( $Fo_{71-74}$ ).

Bickel and Warner (1978) report a small clast (plutonic fragment?) in thin section 77035,71.

Several dark, fine-grained aphanitic clasts are found in the matrix of 77035 (figure 11). They have not been studied.

### Mineralogy

**Pyroxene:** Warren and Wasson (1979), Bersch et al. (1991) and Papike et al. (1994) reported analyses of pyroxene in the brecciated norite clast from 77035 (figure 4). Neal and Taylor (1998) also determined mineral chemistry of the clasts they studied (figure 5).

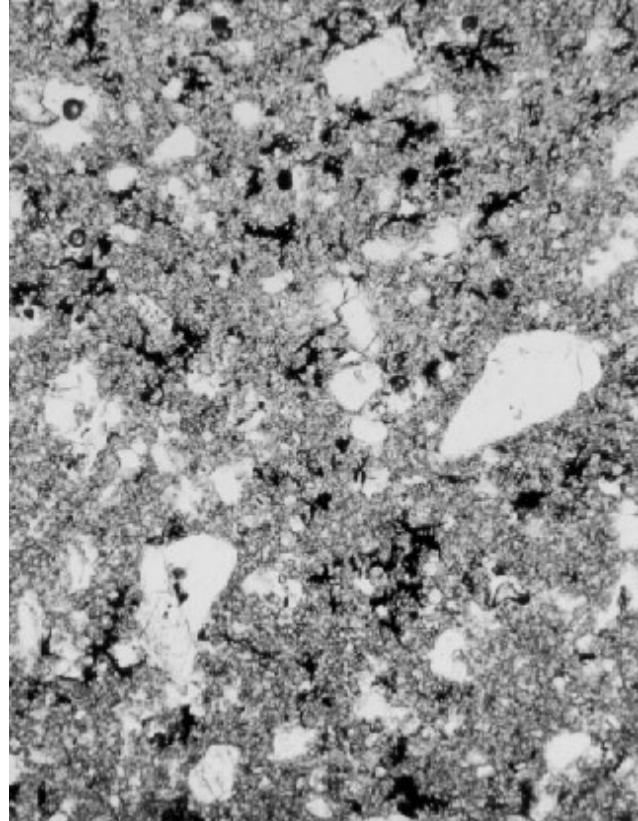


Figure 3: Photomicrograph of matrix of 77035. Field of view 3 mm.

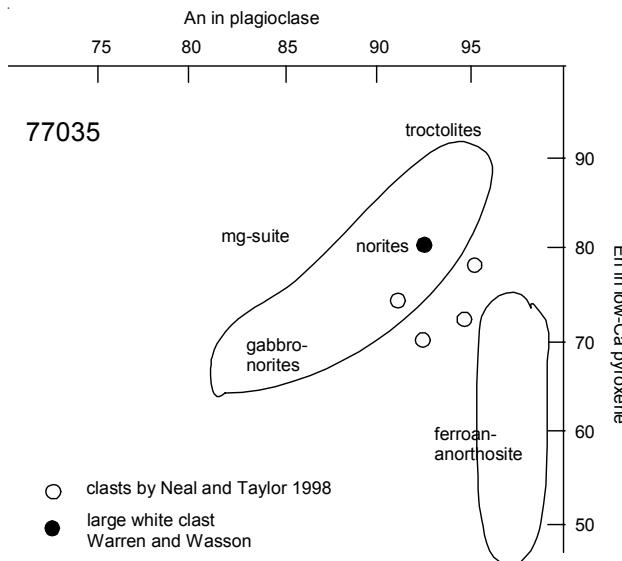
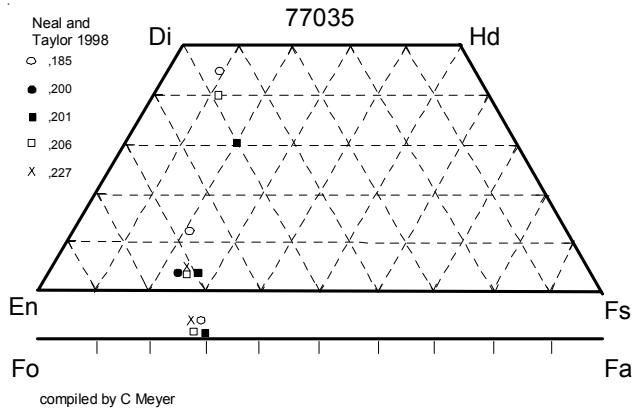
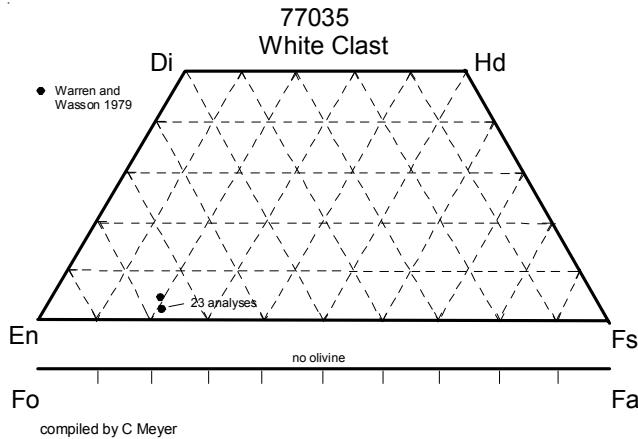
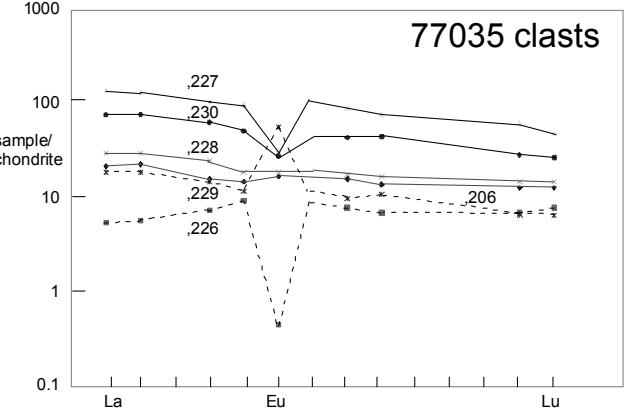
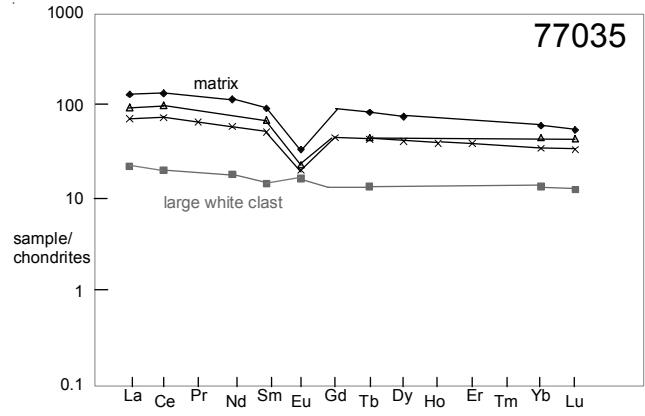


Figure 6: Plagioclase and pyroxene composition for large white clast (norite) and other clasts in 77035. Data from Warren and Wasson 1979, Neal and Taylor 1998.



## Chemistry

Boynont et al. (1975) and Wanke et al. (1975) analyzed the matrix of 77035 and found it to be similar to the Apollo 17 boulders (figure 7). However, Norman et al. (2002) studied a different piece, which may have included an unrecognized clast (table 1). Wanke et al. (1977) report V analyses and Garg and Ehmann (1977) determined Zr and Hf. The Zr/Hf ratio is high. Hughes and Schmitt (1985) discussed Zr-Hf-Ta fractionation during lunar evolution. Javanovic and Reed (1974) determined Cl, F, Br and I. Petrowski et al. (1974) reported C and S.

77035 has a distinctly different siderophile content leading Norman et al. (2002) to conclude that there

**Table 1. Chemical composition of 77035.**

reference	matrix		matrix		large clast		clasts								
	Boynton 75		Wanke 75		Warren 79 norite		Norman 02		Neal and Taylor 1998						
weight	SiO <sub>2</sub> %	46.87	(b)	0.2	(c)	45.3	(d)	0.22	1.48	0.21	0.69	0.68			
TiO <sub>2</sub>	1.38	1.38		1.52	(b)	0.2	(c)	0.87	(d)	0.22					
Al <sub>2</sub> O <sub>3</sub>	17.4	18.1		18.1	(b)	19.09	(c)	15.9	(d)	23.9	0.28	17.1	19.7	27.4	32.1
FeO	6.94	9		8.87	(b)	2.64	(c)	8.12	(d)	5.8	11	8.4	5.8	3.9	2
MnO	0.12	0.11		0.11	(b)	0.09	(c)	0.11	(d)	0.07	0.12	0.11	0.09	0.05	0.03
MgO				12.2	(b)	11.95	(c)	18.9	(d)	7.9	49	11.7	11.9	5.9	4.8
CaO	9.24	11.76		11.23	(b)	11.76	(c)	9.4	(d)	14.6		9.7	12.2	14.2	18.2
Na <sub>2</sub> O	0.6	0.62		0.62	(b)	0.44	(c)	0.45	(d)	0.43	0.02	0.65	0.46	1.21	0.55
K <sub>2</sub> O				0.26	(b)	0.09	(c)	0.15	(d)	0.08		0.3	0.11	0.18	0.32
P <sub>2</sub> O <sub>5</sub>															
S %															
sum															
Sc ppm	13.6	16.8	(a)	16	(b)	10.9	(c)	13.2	(d)	9.4	5.6	15.7	10.1	3	5
V						48			(d)						
Cr	1231	1368	(a)	1368	(b)	2190	(c)	1583	(d)	810	510	1170	1950	440	300
Co	25	32	(a)	32.1	(b)	22	(c)	34.6	(d)	41	62	38	21.4	5.8	4.3
Ni	281	333	(a)	360	(b)	9.5	(c)	294	(d)	560	110	300	26		35
Cu						15.1			(d)						
Zn	2.2	2.4	(a)			1.7	(c)	8.6	(d)						
Ga	5.13	5.02	(a)					3.6	(d)						
Ge ppb	444	433	(a)			3.9 ?	(c)								
As															
Se															
Rb								4.4	(d)						
Sr								138	(d)	180					
Y								75	(d)						
Zr								315	(d)						
Nb								22.6	(d)						
Mo															
Ru															
Rh															
Pd ppb															
Ag ppb															
Cd ppb															
In ppb															
Sn ppb															
Sb ppb															
Te ppb															
Cs ppm								0.18	(d)			0.34	0.4		0.32
Ba								200	(d)	110		350	100	130	240
La	23.4	34	(a)	32.2	(b)	5.5	(c)	17.7	(d)	5.1	1.28	33	7	4.5	18.1
Ce	63	101	(a)	85	(b)	13	(c)	46.5	(d)	14.1	3.5	81	17.8	11.3	47
Pr								6.13	(d)						
Nd								28.3	(d)	7.5	3.4	48	11.3	6.7	29
Sm	10.7	15.2	(a)	14.3	(b)	2.19	(c)	8	(d)	2.27	1.38	14.8	2.89	1.81	7.7
Eu	1.37	1.9	(a)	1.95	(b)	0.93	(c)	1.16	(d)	0.96	0.026	1.78	1.1	3.19	1.58
Gd								9.2	(d)						
Tb	1.7	3	(a)	3.2	(b)	0.49	(c)	1.63	(d)	0.59	0.3	3.3	0.65	0.38	1.6
Dy								10.4	(d)	3.4	1.8	19	4.1	2.7	11
Ho								2.28	(d)						
Er								6.53	(d)						
Tm															
Yb	7.6	11.1	(a)	10.2	(b)	2.2	(c)	5.86	(d)	2.12	1.18	10.3	2.5	1.09	4.8
Lu	1.12	1.5	(a)	1.39	(b)	0.32	(c)	0.85	(d)	0.31	0.2	1.19	0.37	0.16	0.66
Hf	7.4	10.6	(a)	10.8	(b)	1.9	(c)	6.24	(d)	1.72	0.44	12.8	1.71	0.9	5.2
Ta								0.92	(d)	0.2	1.7	1.44	0.24	0.19	0.76
W ppb								0.49	(d)						
Re ppb															
Os ppb															
Ir ppb	5	6.9	(a)	9	(b)	0.05	(c)			37					
Pt ppb															
Au ppb	4.6	5	(a)	4.5	(b)	0.026	(c)			11	6	9	5	6	15
Th ppm	3.7	5.5	(a)	4.5	(b)	1.1	(c)	3.55	(d)	0.93	0.33	5.3	1.38	0.47	2.7
U ppm								0.31	(c)	0.92	(d)	0.2	1.5	0.29	0.8

technique (a) RNAA, (b) INAA, (c) ICP-MS

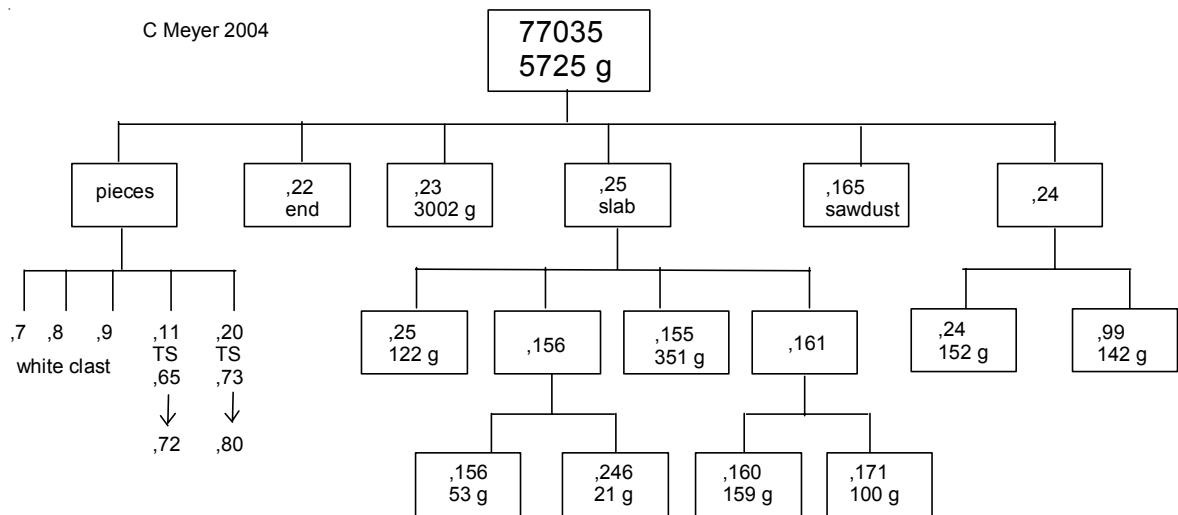


Figure 9: PET photo of 77035 showing banded structure and void space. NASA S73-15904. Cube is 1 cm.

may have been more than one impact event in the region of Serenitatis.

#### Radiogenic age dating

None reported.

#### Other Studies

Sugiura et al. (1978) studied the thermal remanent magnetization in 77035. Simmons et al. (1975) studied differential strain and crack closure in 77035. Horai and Winkler (1976) studied the thermal diffusivity.

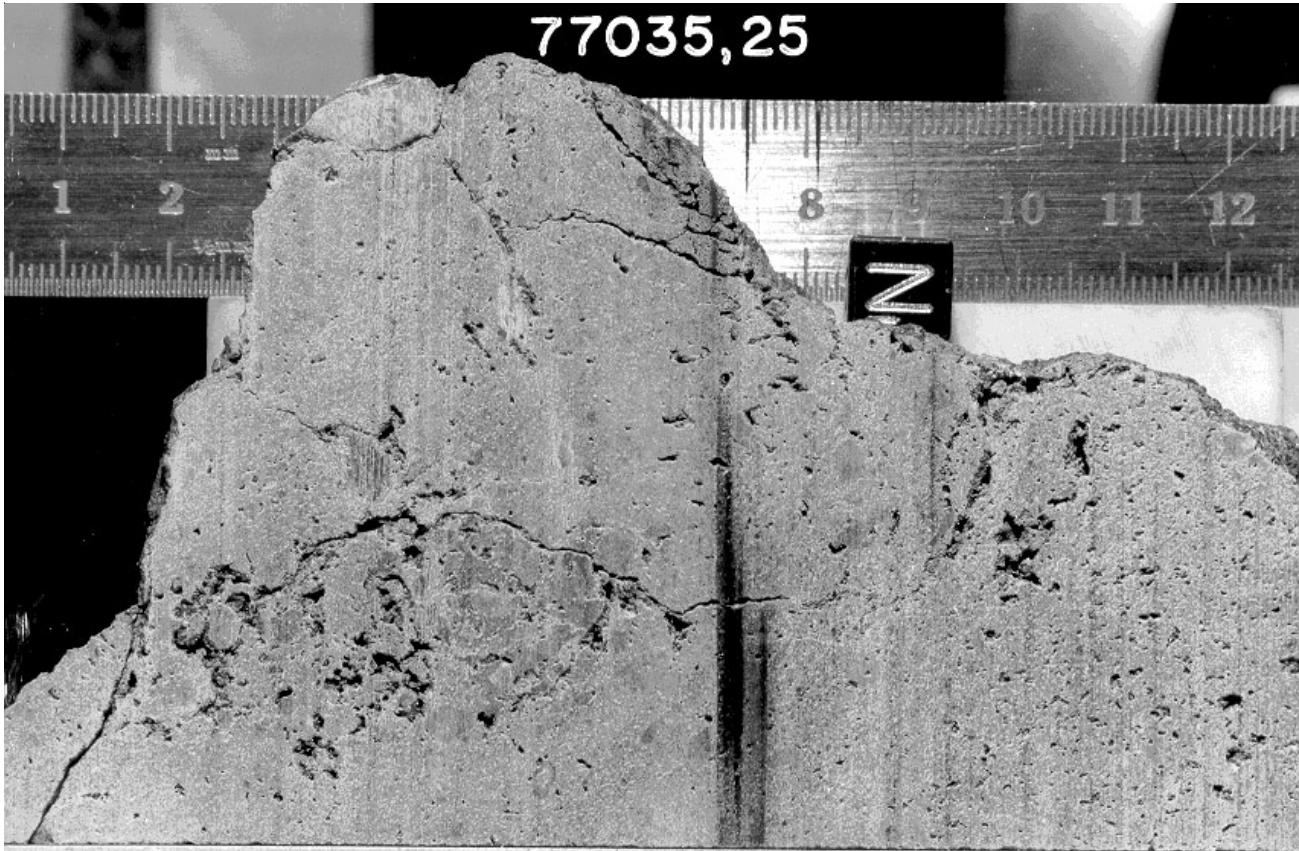


Figure 10: Two sides of slab ,25 cut from 77035. NASA S74-16783 (below) and NASA S74-15068 (above). Cube is 1 cm.

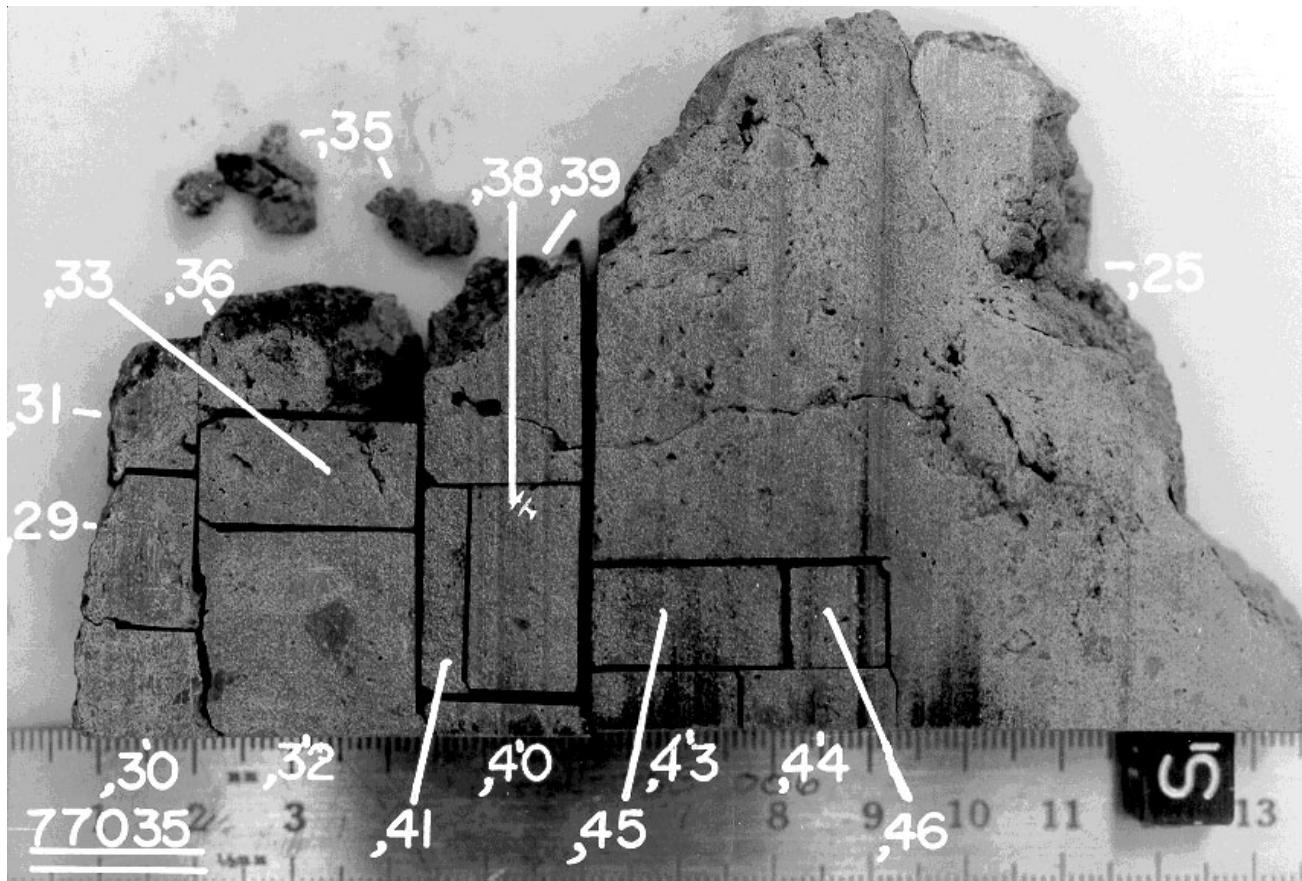




Figure 11: Sawn surface of 77035, 155 showing dark aphanitic clasts in foliated matrix (see also figure 2). NASA S90-28807. Cube is 1 cm.

### **Processing**

A slab was cut through the center of 77035. It proved difficult to sample the small clasts.